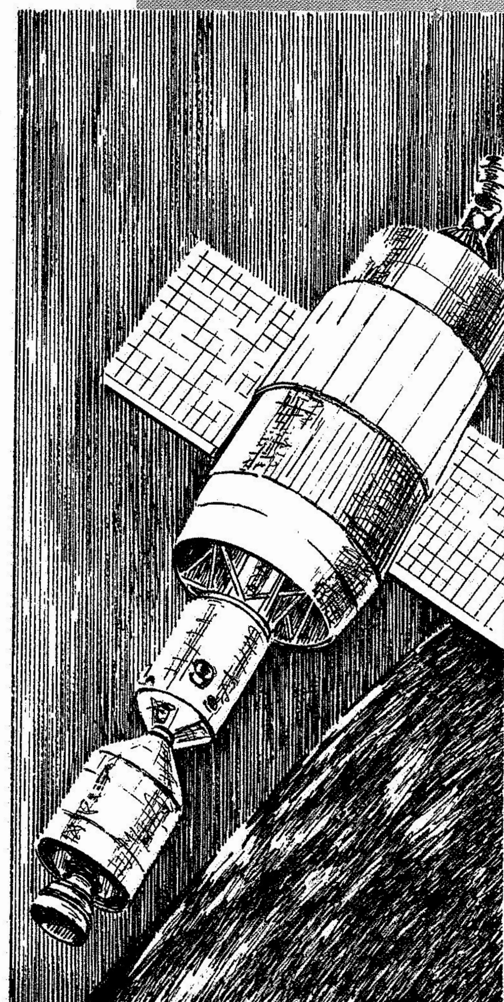
THE FLIGHT EXPERIMENTS PROGRAM

Experiments Office



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GEORGE C. MARSHALL SPACE FLIGHT CENTER

MSFC - Form 3041 (February 1968)

The Flight Experiments Office,

together with the Research Programs Office are the two elements of the Experiments Office, a staff office of the Director, Research and Development Operations, Marshall Space Flight Center. The responsibilities of the Flight Experiments Office include:

a. Program management of flight experiments at MSFC and, in cooperation with the Research Programs Office, the support and encouragement of basic physical research which may later be applicable to the flight experiments program.

b. Identification of new experiments and related research.

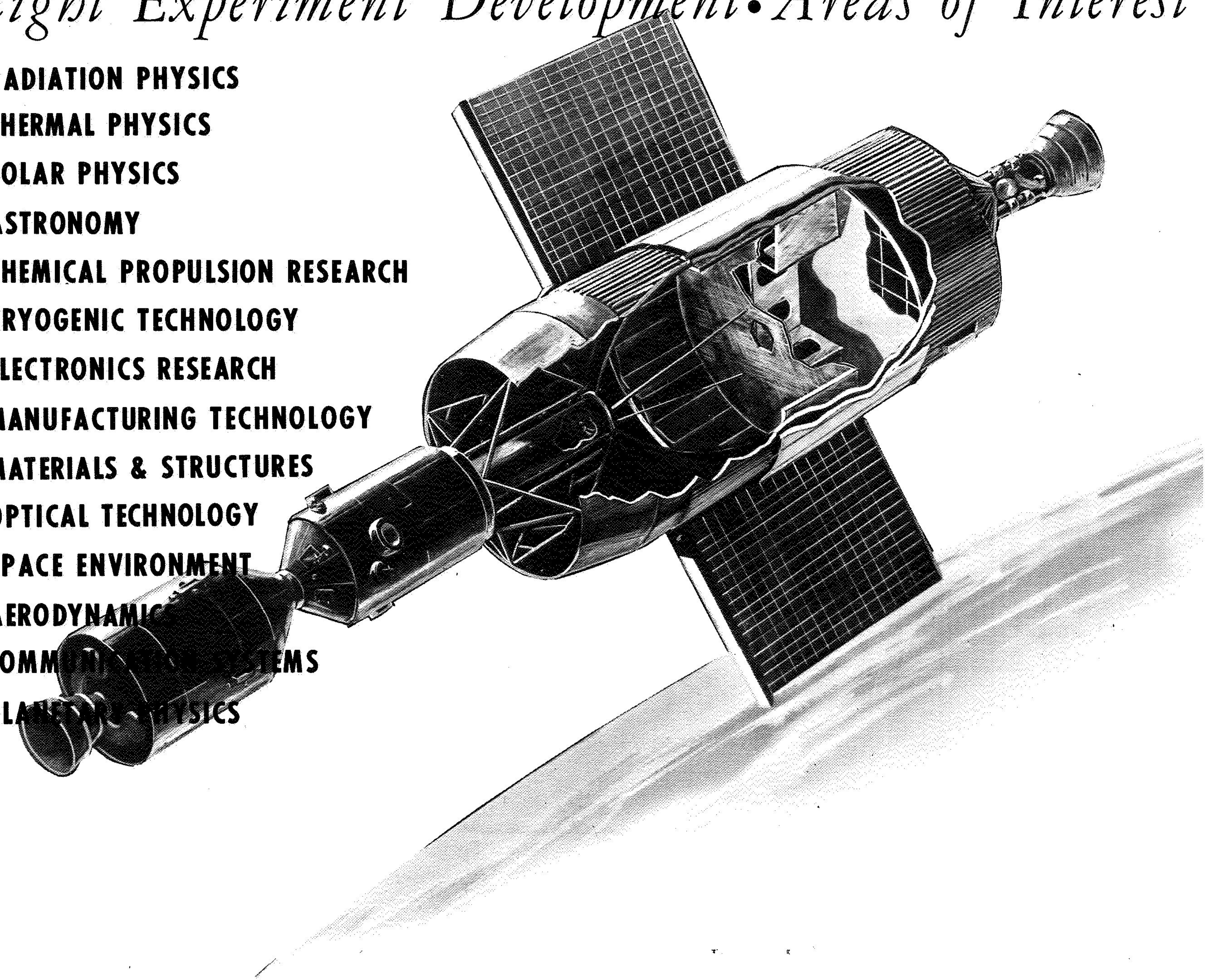
c. Development of a unified program compatible with other NASA missions and coordinated with other government agencies, universities, and industry. Flight Experiments Office personnel are members of several NASA-wide boards and committees.

The current program managed by the Flight Experiments Office consists of approximately sixty experiments being developed by universities, industry, and MSFC Laboratories, in such fields as manned astronomy, cryogenic technology, chemical propulsion, electronics, optical technology, communication systems, radiation, solar, thermal, and planetary physics, aerodynamics, materials and structures, space environments, and manufacturing technology. Because of MSFC's role in the development of launch vehicles, the primary capabilities of the Center are in disciplines most closely associated with that activity; however, the laboratories of the Center are engaged in and provide engineering support to experiments in the broad spectrum of disciplines above. The following pages highlight some of the areas currently being actively pursued.

ROBERT E. LAKE
Robert E. Lake
Flight Experiments Office, R-EO-F
Research and Development Operations
Building 4200
Marshall Space Flight Center, Alabama 35812

Flight Experiment Development • Areas of Interest

- RADIATION PHYSICS
- THERMAL PHYSICS
- SOLAR PHYSICS
- ASTRONOMY
- CHEMICAL PROPULSION RESEARCH
- CRYOGENIC TECHNOLOGY
- ELECTRONICS RESEARCH
- MANUFACTURING TECHNOLOGY
- MATERIALS & STRUCTURES
- OPTICAL TECHNOLOGY
- SPACE ENVIRONMENT
- AERODYNAMICS
- COMMUNICATION SYSTEMS
- PLANETARY PHYSICS



Current MSFC Flight Experiments arrayed by discipline within the responsible laboratory are listed below.

PROPULSION AND VEHICLE ENGINEERING LABORATORY

FLUID BEHAVIOR

MSFC #3 Propellant Mass Determination
MSFC #4 Liquid Interface Stability
MSFC #5 Boiling Heat Transfer
MSFC #6 Cryogenic Propellant Transfer
MSFC #7 Propellant Storage System
MSFC #26 Liquid Drop Dynamics
MSFC #43 Fluid Density Gradient
MSFC #80 Two Phase Flow and Heat Transfer

MATERIALS

MSFC #2 Thermal Control Coatings
MSFC #8 Mechanical Properties
MSFC #9 DC Motor and Gear Lubrication
MSFC #42 Surface Adsorbed Material Collection

AERO-ASTRODYNAMICS LABORATORY

ATMOSPHERICS

MSFC #44 Orbital Density Measurement
MSFC #45 Physics of Gas Surface Interactions
MSFC #46 Orbital Drag Experiment
MSFC #47 Multi-Sphere Satellite

MISCELLANEOUS

MSFC #23 Cross Beam Correlation

SPACE SCIENCES LABORATORY

SPACECRAFT ENVIRONMENT

MSFC #19 Spacecraft Electric Fields
MSFC #66 Contamination Measurement
MSFC #81 Environmental Composition

THERMODYNAMICS

MSFC #54 Behavior of Particulate Materials
MSFC #65 Fusible Material Thermal Radiator
MSFC #84 Spacecraft Surfaces

SPACE ENVIRONMENT

MSFC #67 Earth Albedo Measurement
MSFC #68 Measurement of the Solar Constant
MSFC #72 Cosmic Ray Neutron Albedo Spectrum
MSFC #86 Gravity Gradiometer

LUNAR AND PLANETARY ENVIRONMENT

MSFC #70 Ionosphere Electron Content
MSFC #79 Lunar Orbiting IR Spectroradiometer
MSFC #87 Lunar Surface IR Spectroradiometer

ASTRIONICS LABORATORY

OPTICAL TECHNOLOGY

MSFC #15 Precision Optical Tracking
MSFC #16 Optical Guidance System
MSFC #48 Laser Communications Satellite

MISCELLANEOUS

MSFC #11 Hydrostatic Gas Bearing
MSFC #22 Strapdown Platform
MSFC #49 Galactic X-Ray Mapping
MSFC #63 Extendible Rod
MSFC #64 Gravity Gradient Stabilization of S-IVB

MANUFACTURING ENGINEERING LABORATORY

ASSEMBLY, MAINTENANCE, AND REPAIR

MSFC #34 Space Bonding
MSFC #35 Joining Tubular Assemblies
MSFC #36 Electron Beam Welding
MSFC #57 Gravity Substitute Workbench
MSFC #82 Space Manufacturing Alignment Aid

QUALITY AND RELIABILITY ASSURANCE LABORATORY

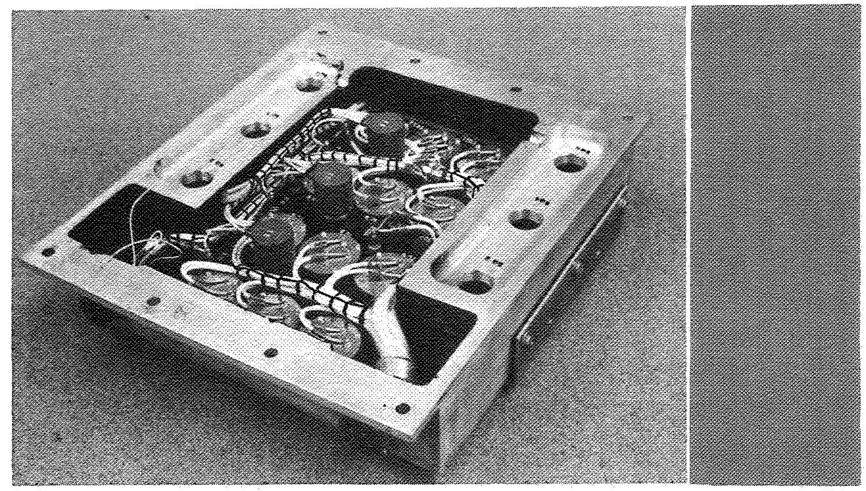
INSPECTION AND CHECKOUT

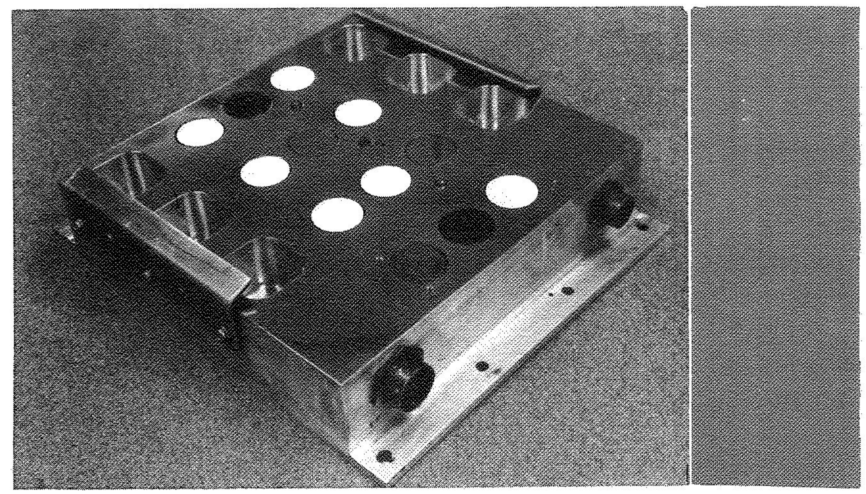
MSFC #27 Fluid Flowmeter Demonstration
MSFC #28 Leak Detector Demonstration

MSFC Experiment No. 2

THERMAL CONTROL COATINGS

The objective of this experiment is to evaluate the stability of thermal control coatings as a function of exposure to pre-launch, launch, and space environments. The thermal control material under test is used to coat small metallic disks which are carefully mounted in housing but are thermally isolated. A resistance thermometer is affixed to the disk. The temperature of the disk, or sensor, is a function of the absorptivity and emissivity of the coating material. Degradation of the coating material is determined from measured deviations of the temperature from calibration values.





Principal elements of this experiment are two panels, each containing 12 thermal sensors, mounted to the exterior of the uprated Saturn I Instrument Unit (IU). The sensors of each panel are arranged in four groups. Each group contains three different thermal control coatings. One sensor of each panel will be covered with a black, totally absorbing, paint to form a "worst" condition baseline from which to correlate the data received from the other sensors. One panel will be placed directly in line with the center of the retrorocket plume and is expected to receive the greater amount of heat from the retrorocket. The other panel will be placed approximately 45° around the IU from the center of the retrorocket and is expected to receive most of the soot and other contaminants from the coolest part of the retrorocket flame. The experiment will be conducted in a series of four exposure conditions. The first group of specimens will be exposed to prelaunch environment, preflight checkout and the entire launch, retrorocket and staging environment. The second group of sensors will be covered and protected until completion of boost phase. The blowoff cover will be removed mechanically, upon command from the IU sequencer just prior to retrofiring so that the sensors will be exposed to the retrorocket flame and all environmental conditions thereafter. The third series of sensors will be covered during all launch and retrofiring phases and will be exposed just prior to the Launch Escape System tower jettison. The fourth series of specimens will be uncovered after the vehicle is in orbit.

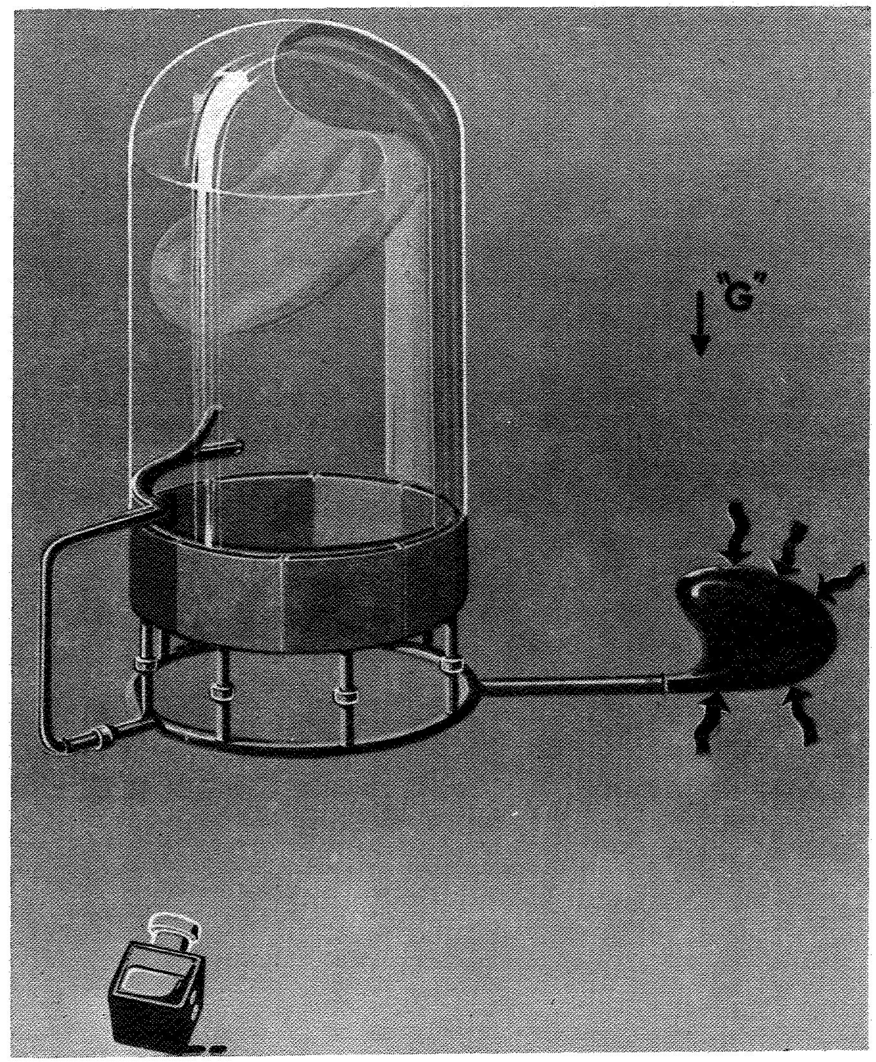
MSFC Experiment No. 3

PROPELLANT MASS DETERMINATION

During orbital operations, measuring propellant mass by liquid level measurement is not feasible because the propellant can be either randomly distributed within the tank or the liquid vapor interface can be otherwise distorted. Therefore, a technique which does not depend on knowledge of bulk density and form and location of the liquid-vapor interface is required. Possible approaches for mass gaging include nucleonic radiation, radio frequency and capacitance techniques.

A small tank (2 ft. diameter, 4 ft. long) partially filled with non-cryogenic liquid is equipped with the mass gaging system or systems to be evaluated as shown in the schematic. The tank is flown as a passenger experiment on the S-IVB/IU. Propellant mass is continuously monitored during conditions of ascent flight and orbital coast. The gaging system accuracy is determined for no-outflow conditions and for conditions of known drain rate.

Experiment definition effort for manned and unmanned versions of this experiment was completed by the Douglas Aircraft Company. For the manned version, this experiment was integrated into one package along with Experiments 4, 5, 6, and 7.



ENERGY TRANSFER BETWEEN FLUID REGIMES

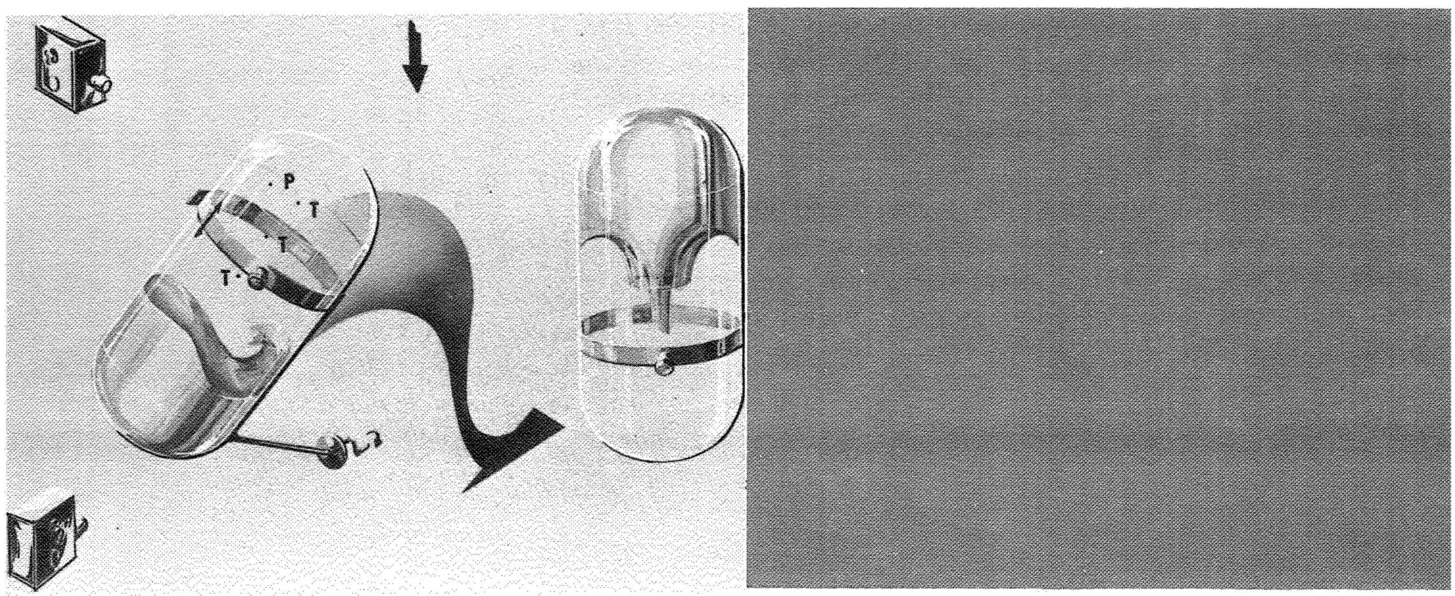
MSFC Experiment No. 4

LIQUID INTERFACE STABILITY

The liquid-vapor interface shape of fluids is a function of the fluid surface tension, the wall configuration in contact with the fluid, and the acceleration of the system. Thus, the interface can assume various shapes between flat, convex, and concave. Since the surface tension varies with temperature, the liquid-vapor interface of a non-isothermal system becomes distorted. Control of the liquid-vapor interface is important in fuel and oxidizer tank systems used in launch vehicles. Because the time available in free fall in drop tower tests is too short to permit stabilization of the fluid system in tanks of appropriate scale size, it is intended to interface stability in flight. The experiment will investigate the effects of tank shape, battling, and non-uniform heating on the liquid-vapor interface while the system is in a low G (10^{-2} to 10^{-4} G) environment. The fluids will be contained in cylindrical and/or spherical tanks made of transparent materials and coated with an electrically conductive film to permit the controlled input of heat at selected points on the tank walls. Low G conditions will be established and maintained for periods sufficient to allow the fluid system to become stable. Visual and photographic observations will be made. Temperatures will be measured. Although ultimate application of the information will be to the design of tanks for cryogenic fluids, non-cryogenic fluid will be used for these tests.

Experiment definition effort for manned and unmanned versions of this experiment has been completed by Douglas Aircraft Company. For the manned version, this experiment was integrated into one package along with Experiments 3, 5, 6, and 7.

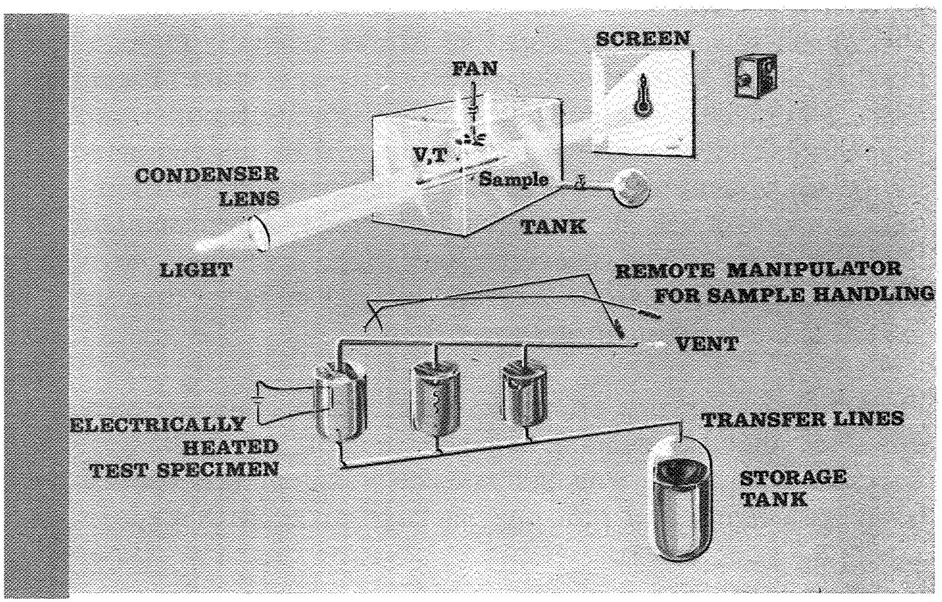
ORBITAL SLOSHING



MSFC Experiment No. 5

BOILING HEAT TRANSFER

The purpose of the experiment is to study the boiling conditions of cryogenic fluids during extended periods of low gravity environment over the range from incipient boiling through film boiling. Similar experiments are being performed in drop towers and have indicated deviations from the boiling conditions at standard gravity in the film boiling and peak nucleate boiling regime. However, the influence of residual flow current during the short drop tower tests cannot be assessed; and thus results may be obscured. Therefore, a long duration space flight experiment is required to establish validity of drop tower testing and to study long duration effects such as bubble migration, coalescence and thermophoretic forces. The application of this knowledge is universal for propellant storage, heat transfer equipment and system design.



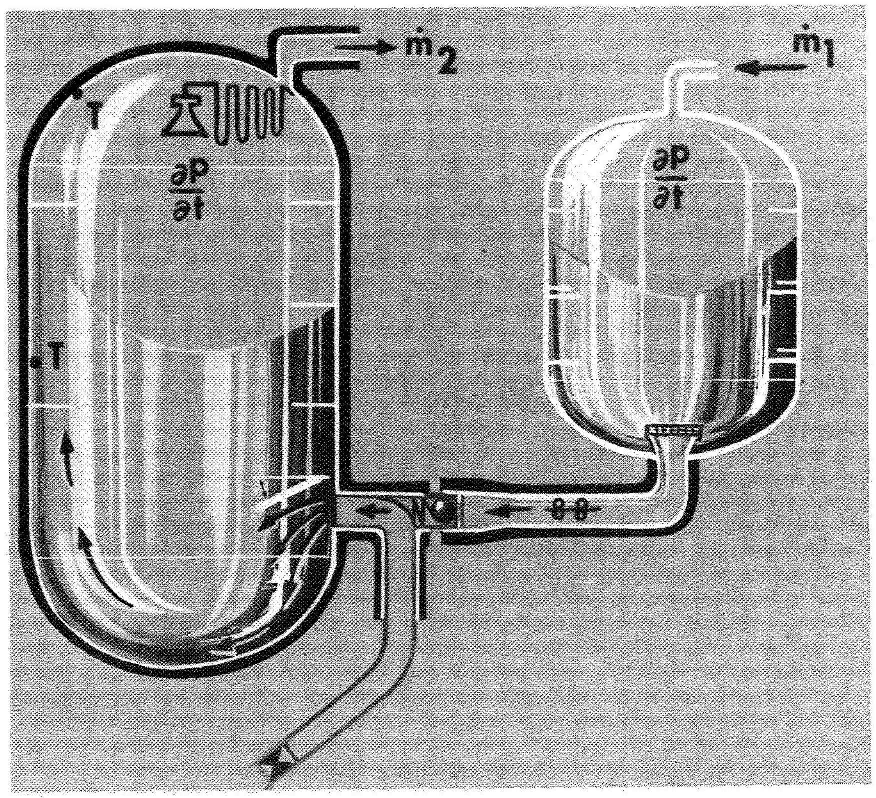
Several small containers (6 cu. ft. each) will be filled with fluid. Each tank will contain a representative heat transfer surface such as flat plates, wires, ribbons and spheres, which can be heated electrically. Observation ports in the tanks will allow photographic coverage and observation of the boiling processes and bubble movement. Test conditions will be readjusted as required. The specimens will be brought to steady state boiling conditions in the various regimes of interest to establish heat flux versus temperature difference relationships. Approximately 10 test points will be taken with each specimen. Preflight access is not required after checkout. Results will be compared with those from drop tower tests.

Experiment definition effort for manned and unmanned versions of this experiment has been completed by the Douglas Aircraft Company. For the manned version, this experiment was integrated into one package along with Experiments 3, 4, 6, and 7.

MSFC Experiment No. 6

CRYOGENIC PROPELLANT TRANSFER

Advanced missions, such as orbiting laboratories or vehicle launch from a space platform require the development of reliable zero gravity cryogenic propellant transfer methods. This problem involves methods for controlling the vehicle center of gravity, pressure rise or decay in the supply and receiver tanks, venting of the propellant tanks during



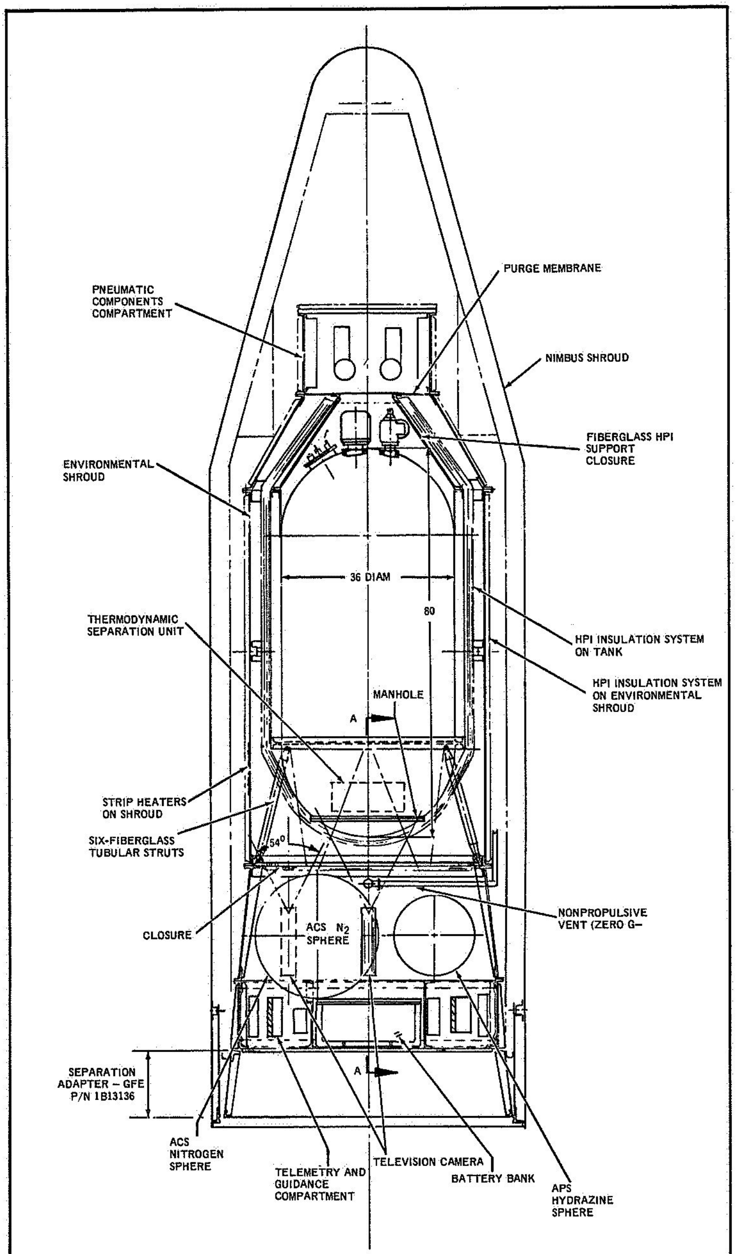
transfer, sloshing of the propellant, and flow energy dissipation in the tanks. It is possible to evaluate such systems only partially under normal gravity conditions since interactions of heat transfer, mass transfer and fluid mixing depend on the gravitational environment. Since the best transfer methods cannot be predetermined, the experimental facilities must be sufficiently flexible to allow the study of several test parameters and variations of these parameters during the same experiment. The experiment will consist of a propellant receiver tank and a propellant supply tank. Transfer between the tanks will be accomplished by pumping and/or pressure feeding. Measurements of tank pressure histories related to transfer rates, initial chilldown and flow detection baffling, will be used to establish optimum transfer conditions.

The experiment will consist of a propellant receiver tank and a propellant supply tank, each about 8 cubic feet in volume. In the area of the propellant fill line the receiver tank will be equipped with baffles that can be manually manipulated to effect adjustable deflection of the incoming propellant. The tanks will also contain a low gravity liquid-vapor separator for tank venting. Both tanks will be instrumented for measurement of pressure propellant and tank wall temperatures, vent and pressurizing flow rates, and propellant transfer rates. The receiver and supply tank will be of identical design to allow back and forth transfers, thus increasing the number of tests per flight.

Experiment definition effort for manned and unmanned versions of this experiment has been completed by Douglas Aircraft Company. For the manned version, this experiment was integrated into one package along with Experiments 3, 4, 5, and 7.

MSFC Experiment No. 7

PROPELLANT STORAGE SYSTEM



PROPELLANT STORAGE SYSTEM(STUDY CONFIG.)

A high performance insulation system is required to store cryogenic propellants in space for extended time periods. To evaluate the thermal performance, vacuum chamber testing of large tanks has been conducted. However, using present ground facilities, it is impossible to simultaneously subject the tank to a complete flight environment of vibration, rapid pressure changes, accelerations, radiation, and solar heat flux. Therefore, orbital testing of superinsulation systems is required to obtain accurate data on system efficiencies. The experimental procedure will subject the tank to the space environment, recording internal tank pressure or vent rate, insulation pressure and stratification. The experiment will consist of a cylindrical superinsulated LH_2 tank of about 16 cubic feet. The tank will be exposed to the ambient pressure environment during ascent flight. In orbit, it will be subjected to the solar heat flux and space vacuum. The tank is instrumented to measure tank pressure, vent rates, insulation pressure and temperature for heat gain calculation. Penetration of mounting struts, valves and fittings will simulate as nearly as possible those required in large vehicle systems. The tank will also serve as a storage reservoir for other fluid experiments which require fluid supply from a storage vessel.

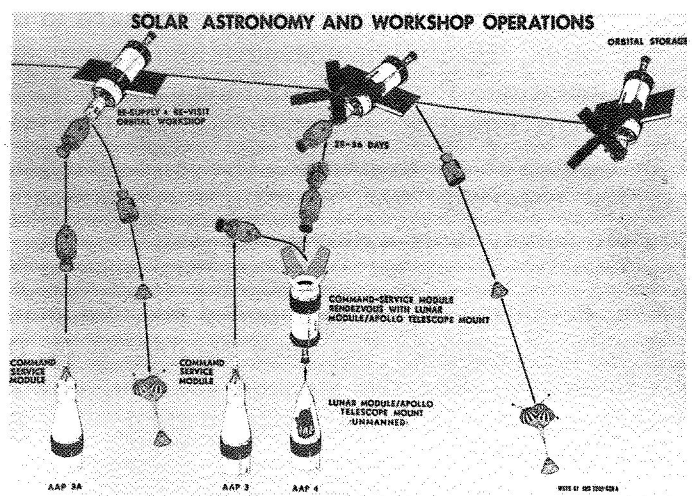
Experiment definition effort for manned and unmanned versions of this experiment has been completed by Douglas Aircraft Company. For the manned version, this experiment was integrated into one package along with Experiments 3, 4, 5, and 6.

MSFC Experiment No. 8

MECHANICAL PROPERTIES

The objective of this experiment is to compare, correlate, or calibrate currently available data on deterioration of specific polymeric materials in simulated environments with actual measurements obtained in space. This experiment will provide a measure of the validity of available data and simulation techniques.

Samples of thin film plastics, elastomers and fabrics will be exposed in the space environment to obtain the full effects of the solar flux, radiation and vacuum. The samples will then be tested in situ to measure stress-strain characteristics in a constant temperature environment so that the data developed will be comparable to existing data. The data will be recorded on tapes and film returned to earth for analysis. No signal handling requirements will be placed on the telemetry system.



MSFC Experiment No. 9

D. C. MOTOR AND GEAR LUBRICATION

This experiment will determine the characteristics and evaluate the design of a high torque dc motor and gear train under load in the space environment, and will compare different lubricants employed in gears and bearings with their performance in laboratory simulated space environmental evaluations.

The motor and gear train test apparatus will be operated continuously for the length of the mission. The set will be operated at a high load to near its point of failure. When an increased torque or temperature signal indicates that a gear or bearing is approaching failure, the test will be interrupted and the worn parts removed by the astronaut for return to earth for analysis and evaluation. The equipment will consist of bucking torque motors of 35 ft. lb. and 7.5 ft. lb. torques connected through a suitable gear train.

Space Craft, Inc., provided conceptual design, experimental hardware design, and developed an engineering test model for this experiment.

The prototype test apparatus will employ bonded thin film dry lubricants (MLF-2 bonded with an organic or inorganic resin) and non-outgassing brush materials of MLF-2 and tantalum for high torque systems in vacuum, high temperature, and vacuum and corona resistant materials (polyimide) in the motor insulation.

MSFC Experiment No. 11

HYDROSTATIC GAS BEARING

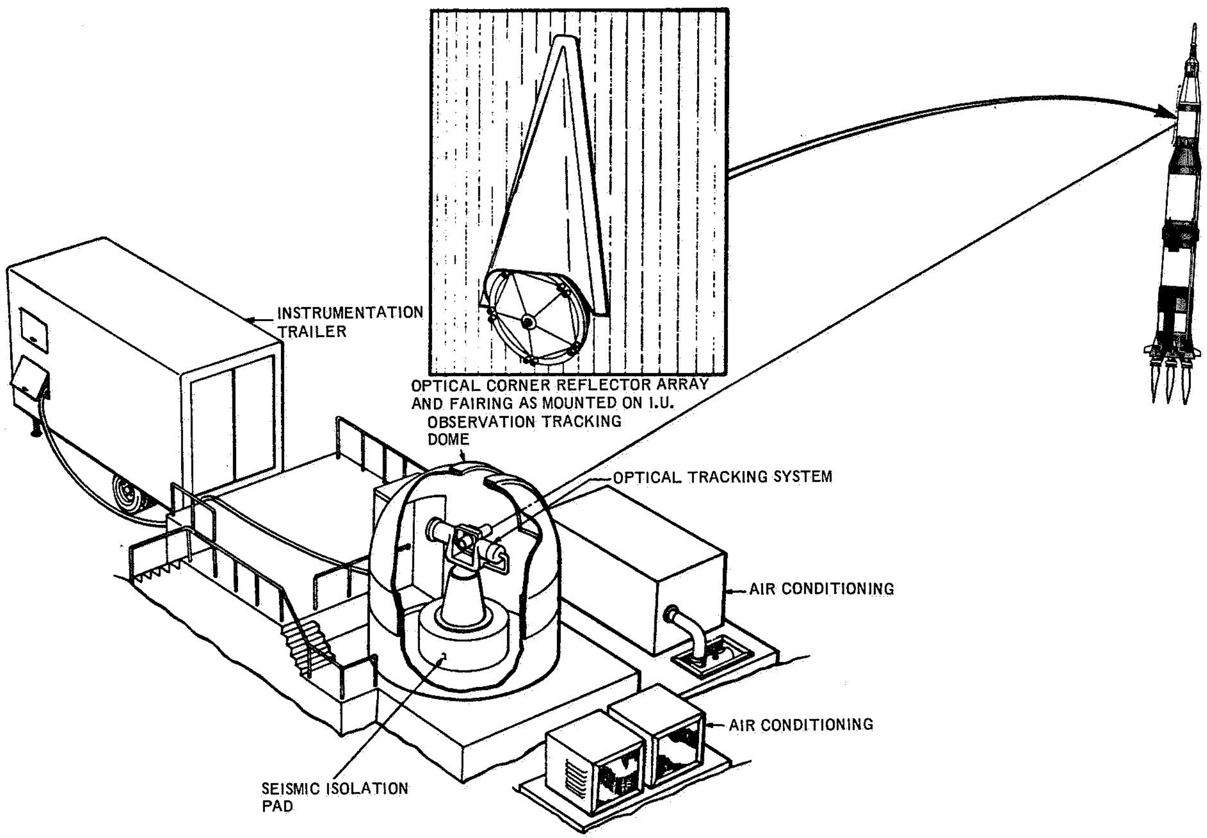
This experiment will obtain data on bearing performance with various differential gas pressures in a zero gravity field. The performance data obtained from the hydrostatic gas bearing experiment will permit analysis and determinations to be made of errors presently attributed to the gas bearing gyroscope during extended missions. It will indicate the feasibility of extending the in-orbit capability of the present guidance system by simply reducing the gas pressure. The data will be meaningful in the design of a gas bearing system which will have a very low gas consumption and will utilize a low power closed-loop gas supply.

The experiment will use two Saturn AB-5 gyroscopes, mounted with one gyro parallel to the longitudinal axis of the vehicle and the other normal to it. Prime measurements will be of the float displacements and torques during a programmed sequence of gas pressures performed each orbit. Data will be collected, stored, and telemetered during this sequence.

MSFC Experiment No. 15

PRECISION OPTICAL TRACKING SYSTEM

This experiment will test and demonstrate an optical system proposed for use as a highly precise tracker during the early launch phases of flight. The system consists of a single station, angle measuring device using a modulated beam from a helium-argon gas laser. The narrow beam of light from the laser is reflected from a corner reflector array mounted on the launch vehicle. The reflected beam is returned to a tracking telescope located coincident with the laser. Range, range rate, angle and angular rate information is obtained. Three test flights are planned for this experiment. Operational characteristics of the system will be observed and recorded. The tracking data obtained will be compared with that obtained from other systems, and with predicted values, to validate the precision of the system.



MSFC Experiment No. 16

OPTICAL GUIDANCE SYSTEM

This experiment will evaluate the performance of an optical guidance system for rendezvous and docking operations. The specific objectives of the optical guidance system experiment are: (1) to evaluate system performance under actual flight conditions, (2) to compare system performance with that of conventional radar systems, (3) to compare the measured performance with the predicted performance, and (4) to determine the system capability under a variety of background conditions.

The experiment consists of a target and a chaser vehicle which will utilize laser/optic techniques for acquisition, tracking, and guidance for rendezvous and docking of the vehicles.

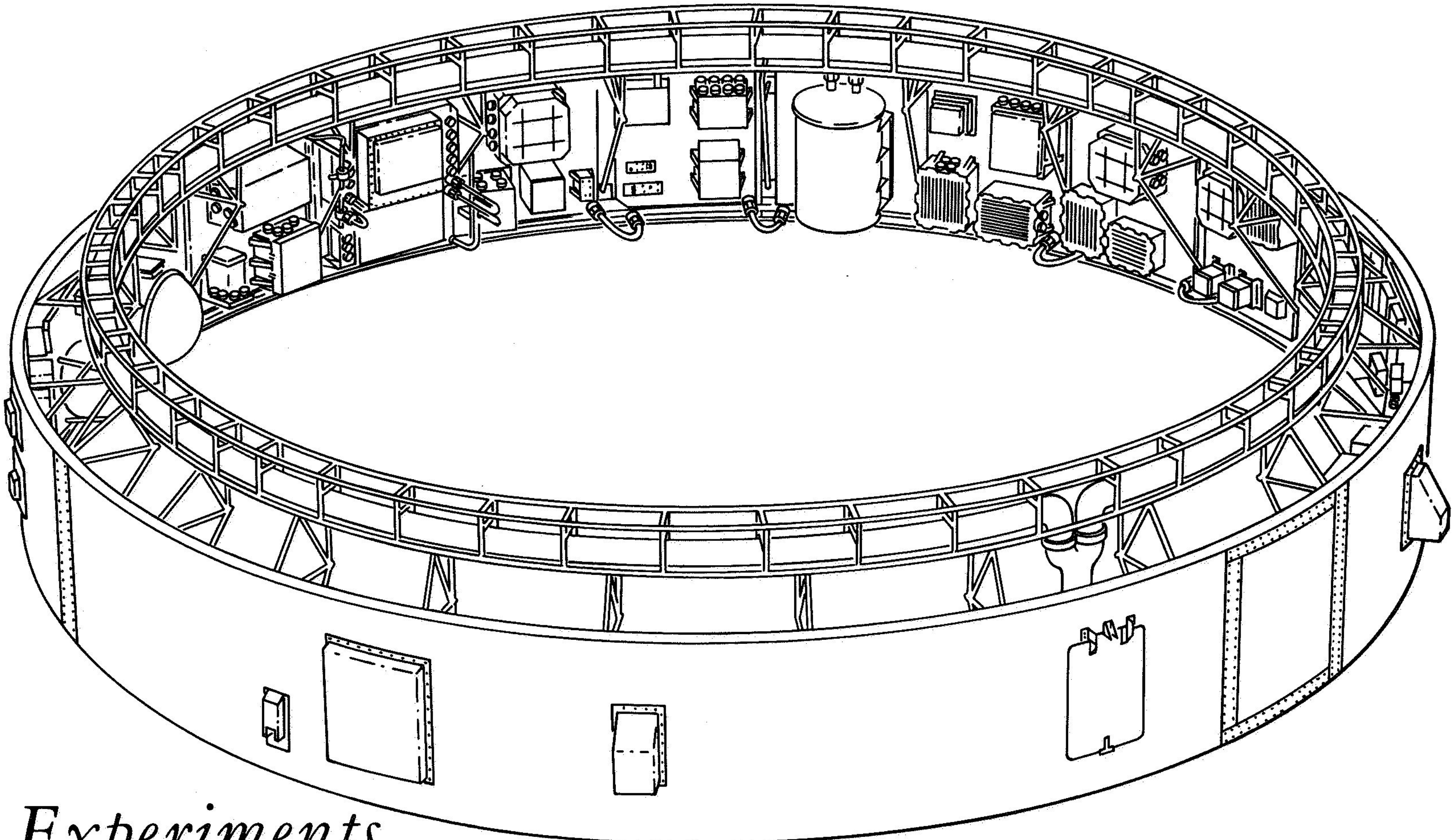
Experiment definition studies have been performed by International Telephone and Telegraph Company.

MSFC Experiment No. 19

SPACECRAFT ELECTRIC FIELDS

This experiment will determine the strength of the electric field associated with a space vehicle. Previous experiments have not yielded satisfactory data because of perturbations created in the field by the measuring instrument. The instrument developed will measure the deflection of an electron beam due to the electric field. It should introduce a smaller perturbing influence than previously used instruments. During preflight testing, emphasis will be placed upon establishing the magnitude and characteristics of perturbations caused by the presence of the measuring system.

Experiment design is being accomplished by Fairchild-Hiller Corporation.



Experiments

EXPERIMENT NO. 11 — HYDROSTATIC GAS BEARING
EXPERIMENT NO. 22 — STRAPDOWN PLATFORM
EXPERIMENT NO. 49 — GALACTIC X-RAY MAPPING

These experiments will be mounted on spare panels in the Instrument Unit pictured above. The Instrument Unit provides all necessary interfaces for these experiments including power, thermal control, and telemetry.

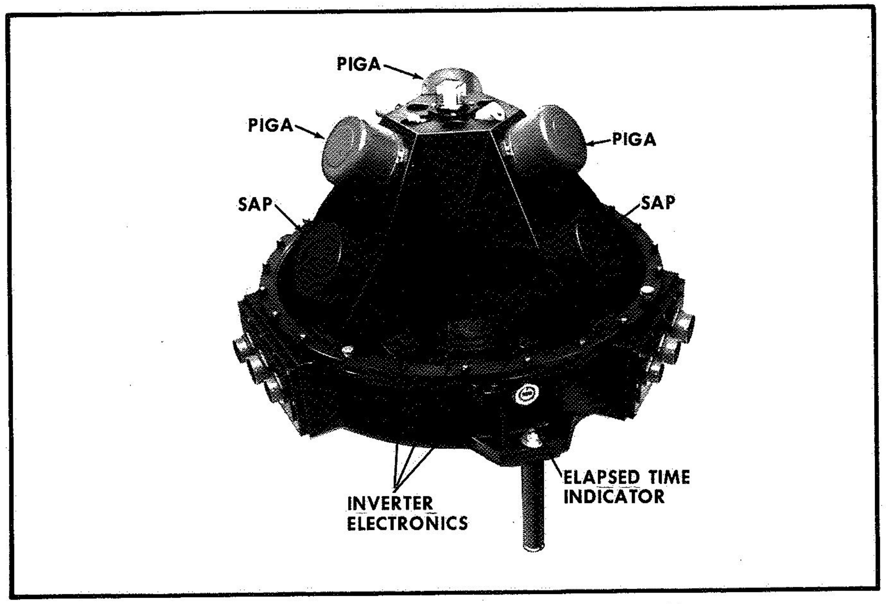
MSFC Experiment No. 22

STRAPDOWN PLATFORM

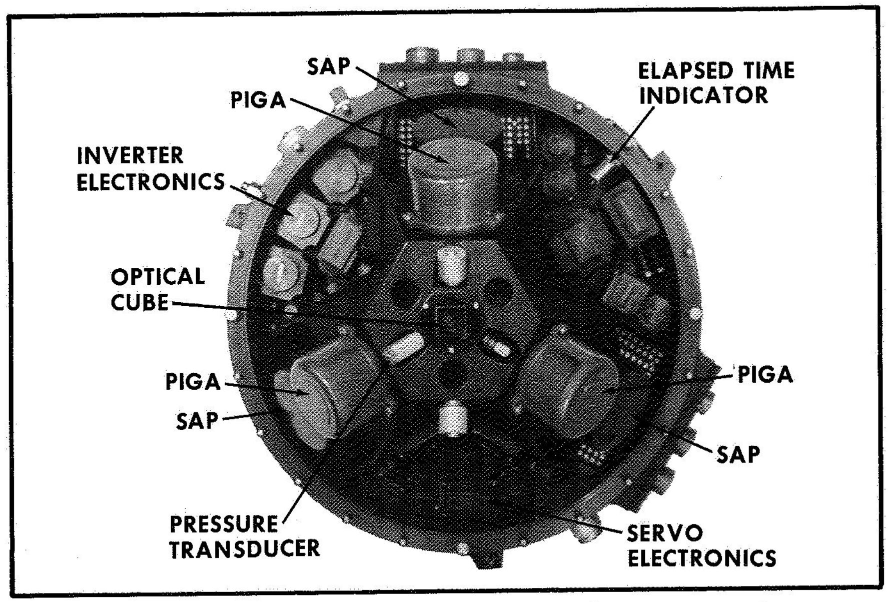
This experiment will be a test of a strapdown guidance system. Strapdown guidance as defined is a system of measuring instruments mounted to the vehicle frame; i.e., gyroscopes and accelerometers that provide information suitable for inertial navigation and the associated computer for interpreting this information, without the need for a gimbal platform. This system will incorporate three Pendulous Integrating Gyro-Accelerometers (PIGA's) which will sense the combined vehicle angular rate and linear velocity changes with relation to the vehicle. Three Single Axis Platforms (SAP's) will sense the angular rate of the vehicle with respect to inertial space in the body-fixed coordinate system.

The attitude data, when combined with the accelerometer outputs, provide the required navigation information.

This sophisticated system will provide the next step in the development of inertial hardware which will eliminate the problems and complexities associated with the present gimbal platform.



INERTIAL MEASURING UNIT

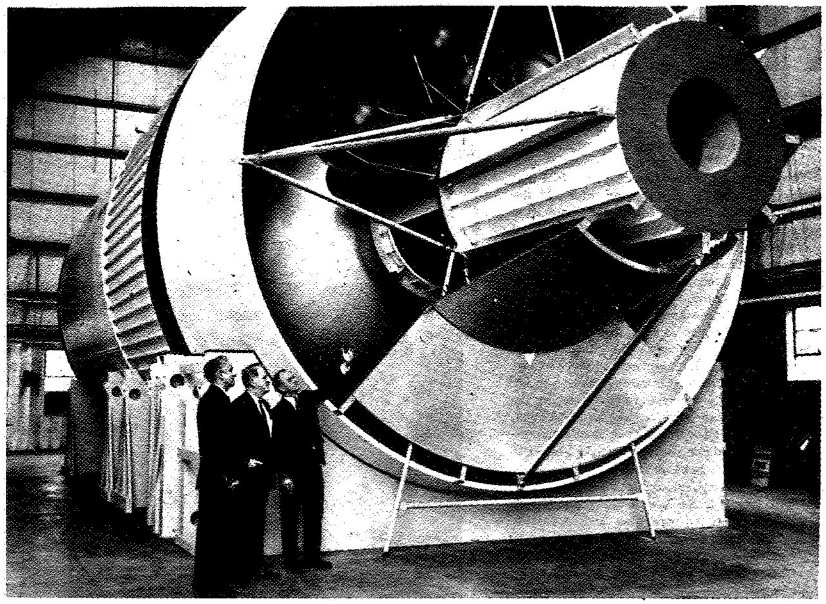


INERTIAL MEASURING UNIT(Top View)

Orbital Workshop

The first Apollo Applications Program (AAP) flights will involve the conversion of the spent second stage of an uprated Saturn I into a comfortable Earth-Orbital Workshop (pictured here). Astronauts will conduct experiments inside this laboratory and around it will be clustered other items of space hardware for research and observation purposes. Most of the experiments described in this brochure are a part of the Orbital Workshop program.

The Workshop will be put into an orbit of 240 nautical miles and will have an orbital lifetime of more than three years. It will be divided into two levels, each level being about 10 feet high and 22 feet in diameter. One level will house the astronauts, while the other will be a laboratory.



EARTH ORBITAL WORKSHOP

MSFC-67-IND 7200-018

S-IVB ORBITAL WORKSHOP

MSFC Experiment No. 23

CROSSED BEAM CORRELATION

The Illinois Institute of Technology and Colorado State University are collaborating on crossed beam field tests. Dr. Gene Sevin of the Illinois Institute of Technology is designing the optical detectors and Mr. V. A. Sandborn, Colorado University, is responsible for data interpretation. The MSFC administrator of this effort is Dr. Fritz Krause, of the Aero-Astrodynamics Laboratory.

The objective of this experiment is to develop a crossed beam remote sensing and measuring system to detect space and time variations of thermodynamic state variables of atmospheric species and atmospheric contaminants. This could lead to observations of clear air turbulence, weather fronts, and ozone motion and distribution (which bears some relation to global weather patterns) and wind altitude profile mapping. The system, when developed, can be operated from satellites and space stations.

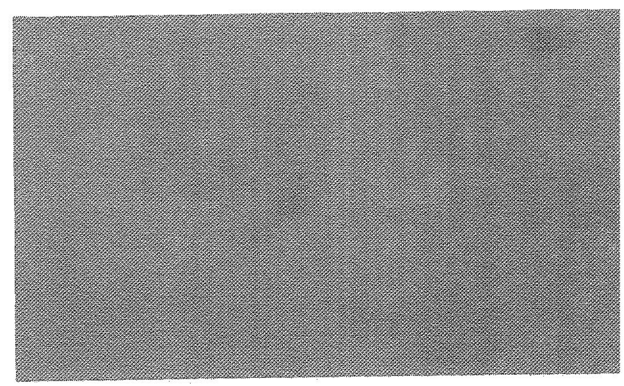
The experiment is currently in the technology development phase. The correlation technique and much of the experimental instrumentation has been proven in wind tunnel tests.

MSFC Experiment No. 26

LIQUID DROP DYNAMICS

This experiment was proposed by Electro-Optical Systems Corporation in response to NASA's invitation to research institutions to use the Apollo program for space oriented research. Dr. Herbert L. Wiser, EOS, is directing this effort.

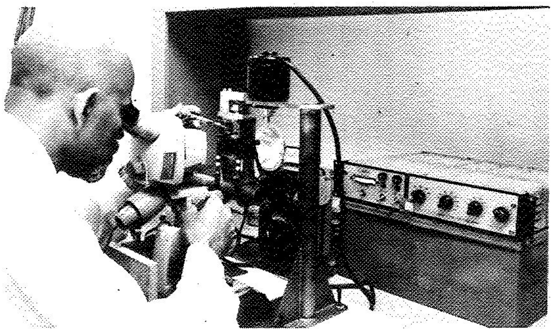
The objectives of the experiment are to study, in zero-g environment the dynamics of freely suspended liquid drops and the effects on drop dynamics of the mixing of drops of different species. Liquid drop dynamics is of major significance in the fields of liquid propellant behavior and surface wave phenomena. The results of these studies will provide tests of existing analytical techniques for treating stable and unstable fluid dynamics. This flight experiment will add to the knowledge of the management and utilization of liquid propellants, and to the design of rocket engine injectors, liquid/vapor separators, and slosh baffles.



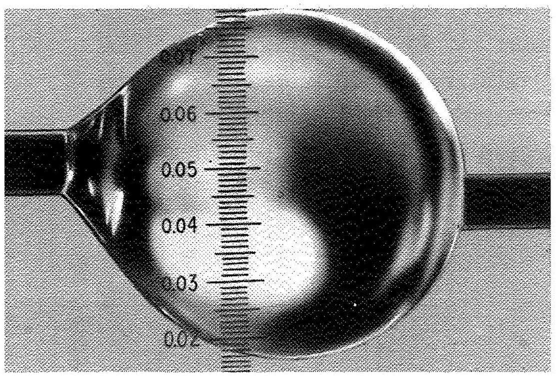
MSFC Experiment No. 27

FLUID FLOWMETER DEMONSTRATION IN SPACE ENVIRONMENT

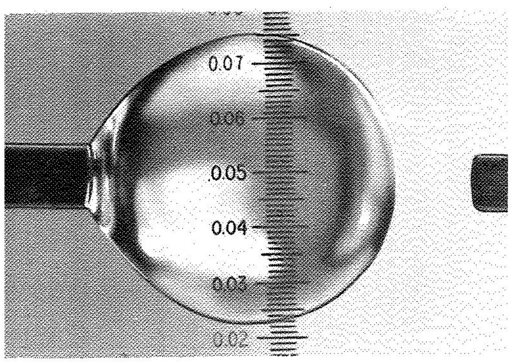
The fluid flowmeter will be used to measure leak rates at collecting points such as double sealed flanged joints and will also be used to measure required purges at such points as propellant pump purge cavities. The device will be a hand-held self-powered instrument that will exhibit no sensitivity to the effects of the high vacuum of space and will be independent of the forces of gravity for its operation. The flowmeter will incorporate a visual display on a lighted dial which is graduated and numbered. The readings required for data use will be to the nearest graduation with no interpolation desired. The dynamic range will be a function of the instrument itself and places no requirement on the astronaut for data handling.



DROP DYNAMICS TEST APPARATUS



STATIC GLYCEROL DROP 1.4M/M DIAMETER MAGNIFIED 28 ×



GLYCEROL DROP 1.6 M/M SPINNING AT 2,800 RPM

MSFC Experiment No. 28

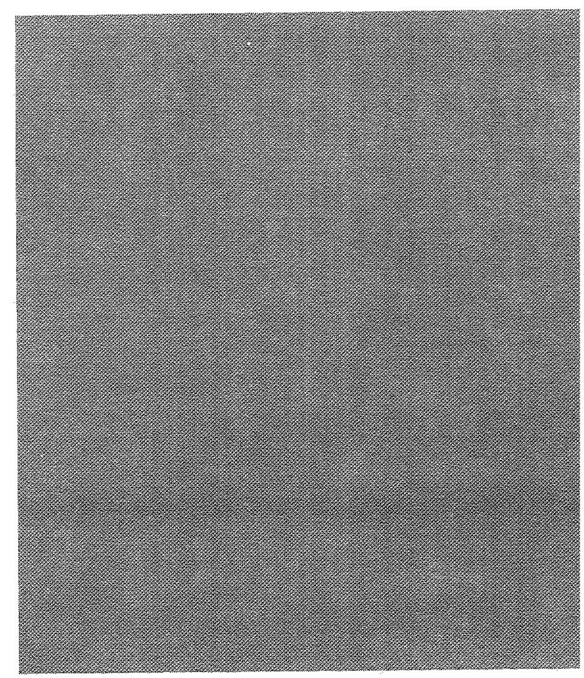
LEAK DETECTOR DEMONSTRATION

The leak detector will be used to perform checkout on vehicle fluid systems that are to be maintained, repaired or assembled in a space environment and will enable the astronauts to make pressure measurements of gas leaks. In addition, the device can be used as a pressure gauge to determine space environment conditions. The detector is a hand-held self-powered device that will furnish the astronauts data output by means of a visual display as a conventional electrical meter, marked in dimensionless units from 0 to 10. These readings, produced while sweeping the detector over fuel lines, will be produced as a result of leaks detected by the device. The detector is intentionally designed so that it is directional in operation. Pressure measurements of gas molecules being emitted from a leak source will be relatively easy to detect as the mean free path of the molecules in the environment of space is quite significant. Sensitivity of the instrument is sufficient to measure leaks in the order of 1×10^{-6} scc/sec, and absolute pressure from 1×10^{-4} to 1×10^{-10} torr.

MSFC Experiment No. 34

SPACE BONDING

This experiment developed by the Whittaker Corporation will substantiate, by in-flight demonstration, that conventional adhesive bonding materials and methods can be used for repairing space vehicle structures. The flight hardware will be tested under laboratory conditions using a modified space suit developed by Litton Industries. The tests will prove the bonding ability of the adhesives being evaluated under a vacuum approaching that of space as well as develop application techniques for use in the space environment.



MSFC Experiment No. 35&36

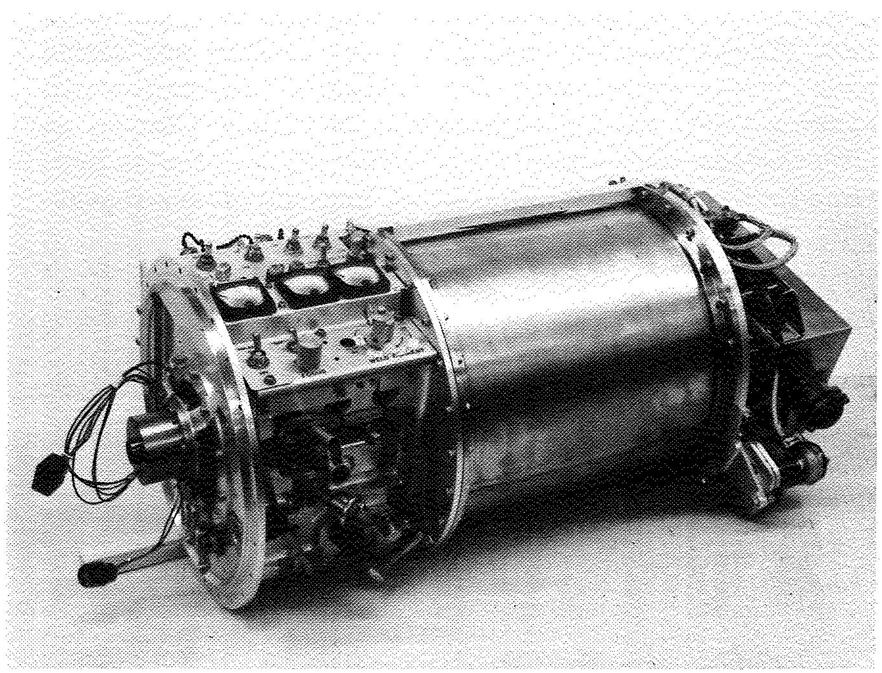
JOINING TUBULAR ASSEMBLIES

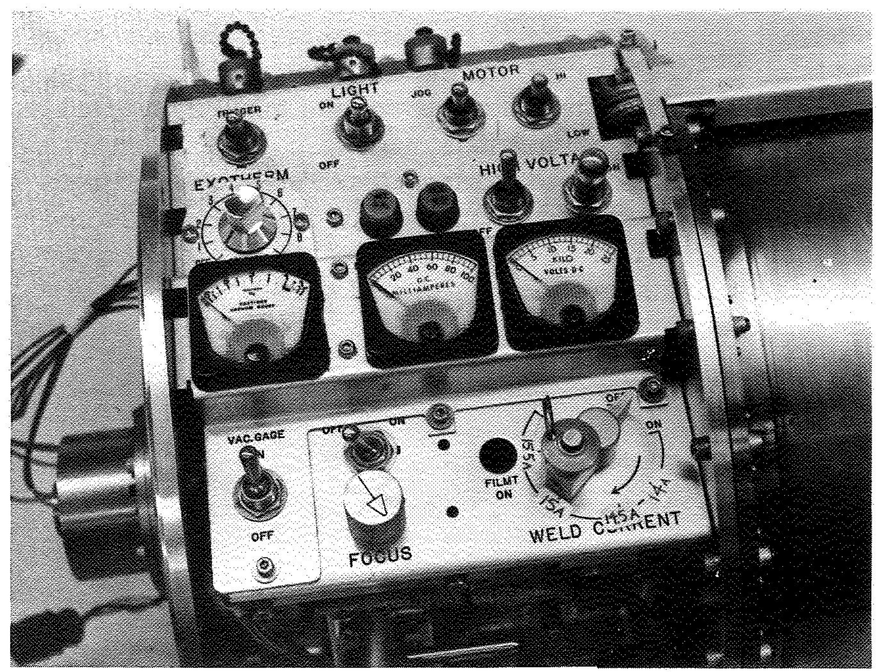
ELECTRON BEAM WELDING

These two experiments are a part of a planned program to develop reliable procedures for joining metals in space. The program is divided into several experimental phases. These two experiments will determine the feasibility of welding space assemblies. The principal objective of both experiments is to determine the significance of gravity on the fusion process.

An electron beam welder and pre-formed specimen are provided in a package which composes both a storage case and a work area for the experiment in space. The astronaut will carry out a program of welding using the electron beam welder and the samples. These welded samples will be packaged and returned to earth for analysis. Additionally, the astronaut will observe the weld puddle and will note deviations in its characteristics from those normally obtained in the one-g field.

The exothermal brazing experiment will consist of a package of tubular samples and of sleeve joints around each of which is fitted an exothermic material. The astronaut will conduct brazing operations in space using the samples provided. The brazed samples will be returned to the earth for laboratory analysis.





MSFC Experiment No. 42

SURFACE ADSORBED MATERIAL COLLECTION

The experiment is designed to collect and analyze specimens of materials which adsorb on spacecraft surfaces. It is one of several related experiments which are being conducted for the purpose of identifying and controlling expected contaminants which deleteriously affect spacecraft performance and the performance of other, scientific experiments.

Specimen collectors are made of three inch by three inch fritted glass slides, secured by means of holding brackets, at several locations on the space vehicle. Mounting positions are selected such that good exposure of collectors to suspected major sources of contaminants is assured while maintaining accessibility by the astronaut in flight. The sample holders are designed for ease of handling. Specimens to provide baseline data will be collected prior to launch. Specimens exposed to launch and staging operations will be collected after orbit is achieved. The collected specimen slides will be sealed in a container and returned to the earth for laboratory analysis of the adsorbed materials.

MSFC Experiment No. 43

FLUID DENSITY GRADIENT

This experiment was originated by Electro-Optical Systems, Inc., in response to NASA's invitation to research institutions to use the Apollo program for space oriented research. Dr. Herbert L. Wiser, EOS, is directing this effort.

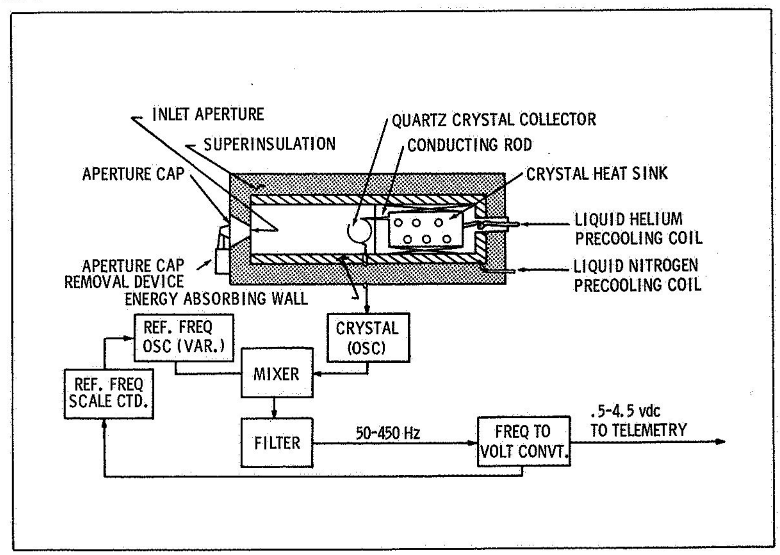
The objective of the experiment is to study the pressure-volume-temperature (P-V-T) characteristics of a fluid at critical and near-critical conditions at reduced gravity. Thermal conductivity will also be studied. Opalescence and light scattering will be observed and recorded photographically. This experiment must be performed in orbit under zero-g. Liquids in the one-g field undergo drastic changes in density and surface tension in approaching the critical state. These features should be more evident and stable under zero-g conditions. The absence of convection will permit a more careful examination of a liquid (Xenon) as it approaches the critical point. The results of tests performed on earth are not satisfactory because of non-repeatability caused by the density gradient.

MSFC Experiment No. 44

ORBITAL DENSITY MEASUREMENT

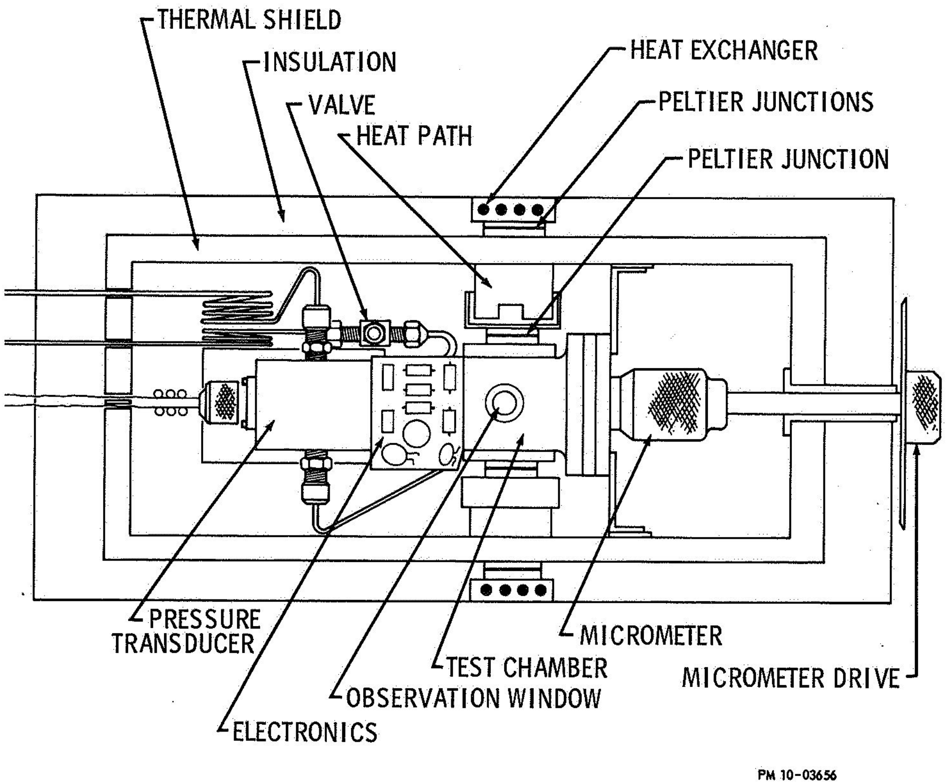
The principal investigator for this experiment is Dr. R. L. Chuan, Celestial Research Corporation, who is directing the effort. Nortronics/Huntsville, segment of the Northrop Corporation, is conducting a study to establish the feasibility of incorporating this experiment and Experiments MSFC #45, 46, and 47 into one carrier, ODYSSEY I.

The objective of this experiment is to make measurements of density and composition of the ambient environment at satellite orbital altitudes. The experiment will consist of a combination of cryogenically cooled piezoelectric mass-sensitive quartz crystals and a mass spectrometer on an attitude controlled satellite. Continuous measurements of density and composition of the ambient environment will be made.



DENSITOMETER SCHEMATIC

CRITICAL STATE EXPERIMENT



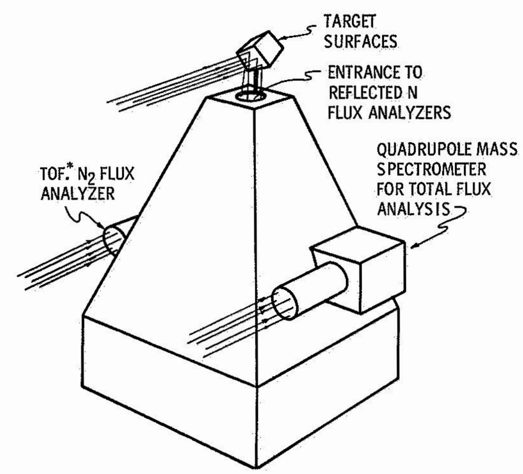
MSFC Experiment No. 45

PHYSICS OF GAS-SURFACE INTERACTIONS

The main objective of this experiment is to explore the interactions of nitrogen molecules with simulated engineering and scientific target surfaces under conditions of relative velocity and general environment found on an earth satellite. The nitrogen molecules which strike the satellite are scattered in all directions; the angular distribution of the molecules which scatter from a target surface is to be measured. The velocity of the Nitrogen (N_2) molecules relative to the satellite before impact is relatively uniform and is on the order of 10^6 cm/sec; their velocity distribution after scattering is to be measured. An additional objective is the measurement of the composition of the total molecular flux incident on the satellite. The experiments as currently conceived are operable between 100 and 350 km altitude.

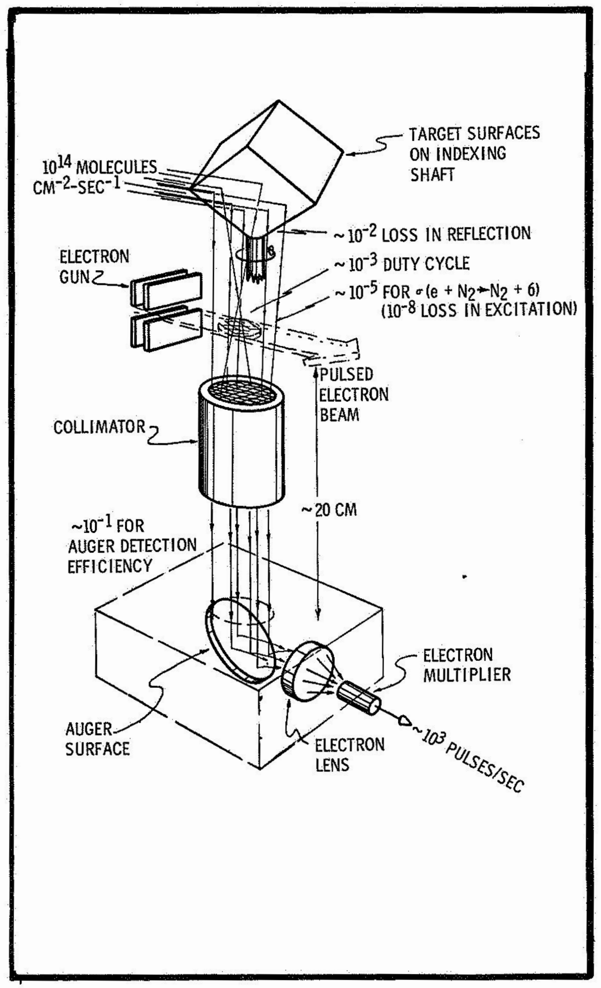
The general features of the experiment are shown in this figure. A quadrupole mass spectrometer to measure the composition of the incoming flux is shown on one side. An instrument for measuring the flux of N_2 alone is on the other side. Centered between these two instruments is an enclosed analyzer which is used for the measurement of the angular distribution and velocity distribution of the nitrogen flux which is reflected from a target surface. Molecules strike the target surface at an angle determined by the attitude of the satellite with respect to its velocity vector.

GENERAL VIEW
OF PROPOSED EXPERIMENT

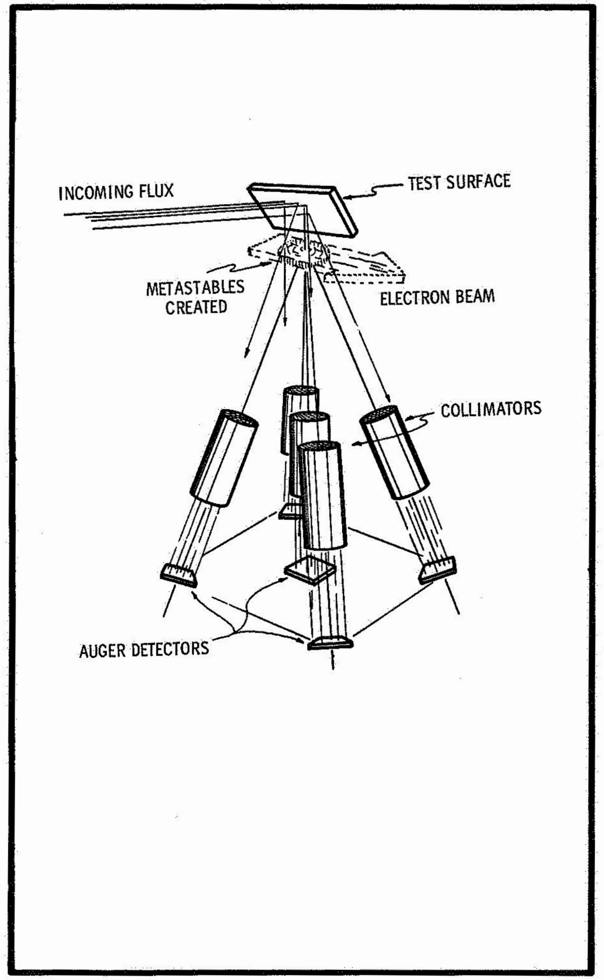


* TOF = Time of Flight

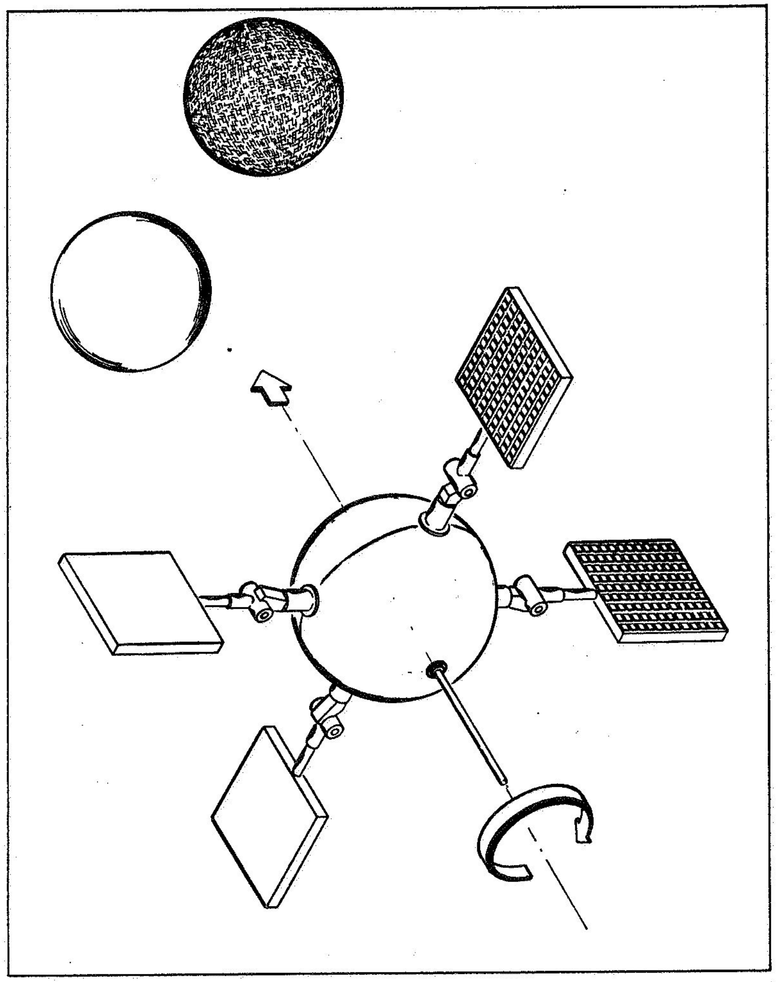
N_2 TOF ANALYSER OPERATION



MEASUREMENT OF DISTRIBUTION OF REFLECTED FLUX



PADDLEWHEEL/DIFFUSE
AND SMOOTH SPHERES EXPERIMENT



MSFC Experiment No. 46

ORBITAL DRAG EXPERIMENT

This experiment was originated by Dr. O. F. Moe, University of California, Los Angeles, who is directing the overall effort.

The experiment objectives are to determine the ambient atmospheric density and the energy accommodation and reflection coefficients for high energy (approximately 1 to 10 electron volts) neutral atmospheric particles impacting orbiting vehicles. Better knowledge of these gas molecule-surface interaction parameters will result in more realistic and accurate computations of orbital aerodynamic parameters such as drag coefficients, normal force coefficients, and axial force coefficients.

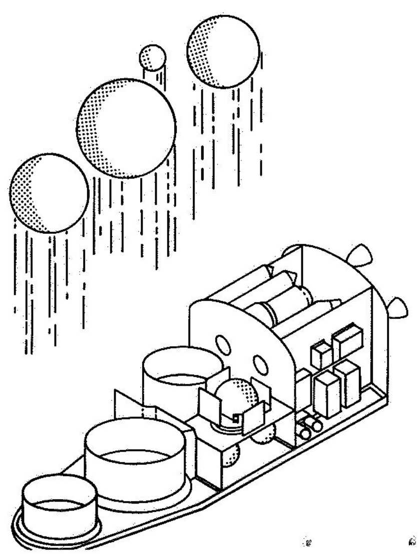
The experiment will consist of a spin-stabilized paddlewheel satellite, a smooth sphere, and a diffusely reflecting sphere placed in a highly elliptic orbit (perigee - 200 km; apogee - 2000 km) with the spin axis of the paddlewheel aligned with the velocity vector of its motion at perigee.

MSFC Experiment No. 47

MULTI-SPHERE SATELLITE

This experiment was developed by Dr. C. O. Lundquist, Smithsonian Astrophysical Observatory, and scientists in MSFC's Aero-Astrodynamics Laboratory.

The objectives of the orbiting sphere experiment are to determine the ambient density and aerodynamic drag coefficient of near-free molecular flow in the 140-200 km altitude region; to investigate aerodynamic effects in free-molecular, near-free molecular, and transition flow regimes; and to obtain additional geodetic information. An ensemble of four passive spheres with identical smooth surfaces and varying area/mass ratios will be placed in an orbit with a perigee of 160 km and an apogee of 1700 km. Tracking will be accomplished by the Baker-Nunn camera system of the Smithsonian Astrophysical Observatory. Refined orbit decay analytical techniques will be used to obtain the data which will consist of precise orbital decay rates for each of the spheres.



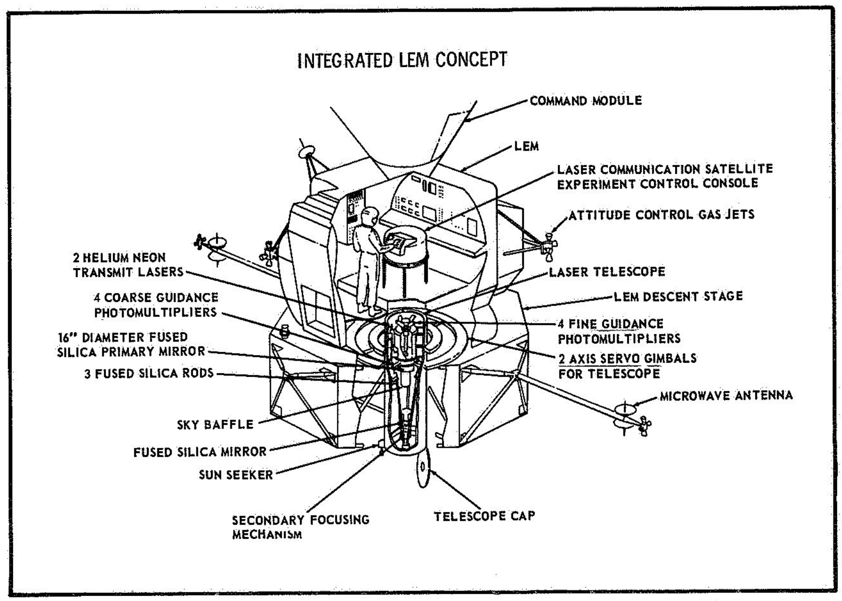
MSFC Experiment No. 48

LASER COMMUNICATION SATELLITE

The Perkin-Elmer Corporation performed early definition studies on this experiment in conjunction with the Optical Technology Experiment Satellite effort.

The purpose of this experiment is to develop and demonstrate the scientific and engineering technology required for a high-data-rate deep space optical communication system.

An optical transceiver will be placed on earth and one in space with an optical link or beam being established between the two stations. A synchronous earth orbit is required to simulate communication between earth and a deep space vehicle using laser/optical techniques.



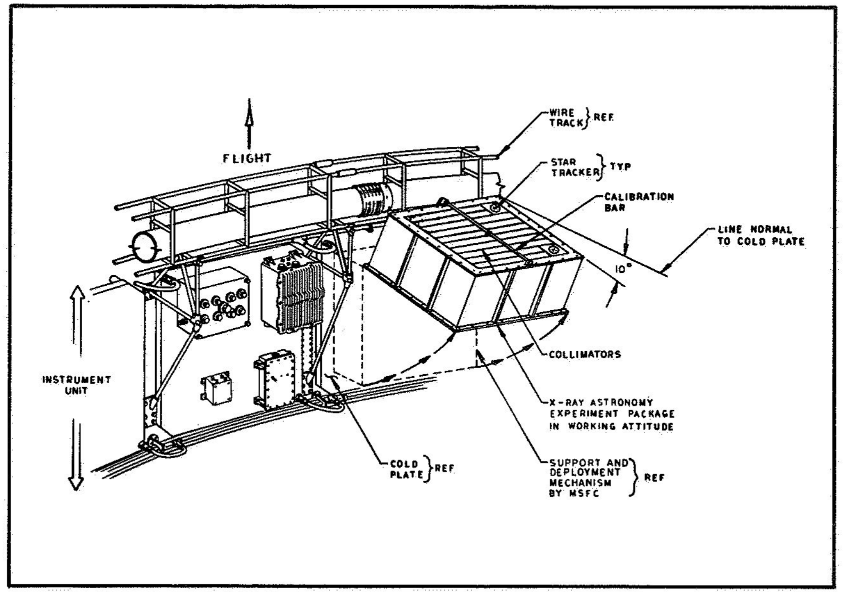
LASER COMMUNICATION SATELLITE EXPERIMENT

MSFC Experiment No. 49

GALACTIC X-RAY MAPPING

This experiment is being conducted by Dr. William Krashaar of the University of Wisconsin. Dr. Krashaar is developing the experimental apparatus. The Center is providing specialized engineering support of the development effort and will be responsible for integrating the experiment package into the space vehicle.

The objective of the experiment is to explore and map X-ray sources in that portion of the sky, about one sixth the celestial sphere, which will be visible to an X-ray telescope mounted as a passenger experiment in the Instrument Unit of an improved Saturn launch vehicle. The planned observation time is the 4.5 hour period of active Instrument Unit lifetime after the vehicle has attained orbit. The X-ray detectors are Xenon filled proportional counters. Data will be stored aboard the vehicle as collected and read out upon command during passage over ground telemetry stations. Analysis will be performed by the principal investigator.

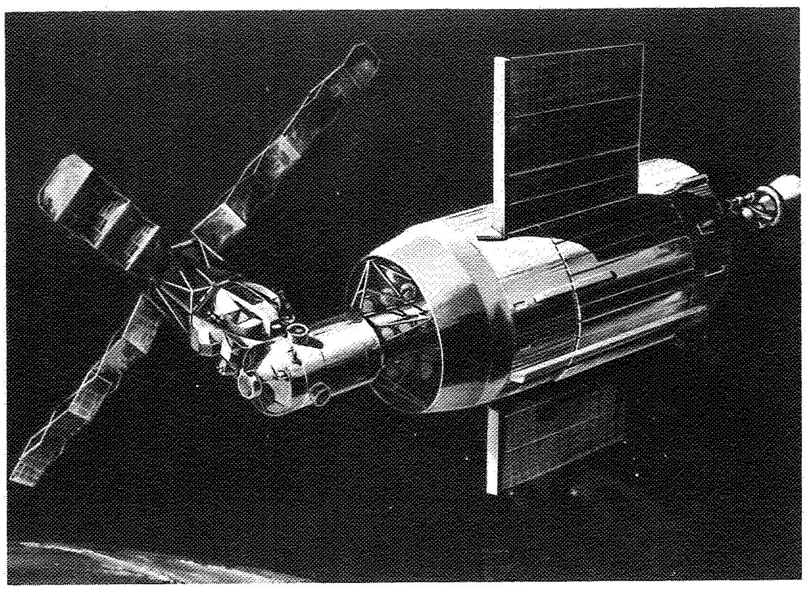


X-RAY ASTRONOMY EXPERIMENT

MSFC Experiment No. 54

BEHAVIOR OF PARTICULATE MATERIALS

The experiment will investigate the macroscopic behavior of particulate materials in a zero gravity environment with various applied temperatures and acoustic fields. The applied acoustic fields are used to determine the adhesion of the particles. The data from this experiment will further the basic understanding of thermal conduction and radiation. Much work has been done in the laboratory to investigate these phenomena in one-g field and some data are available from experiments conducted during low-g periods on aircraft flights. The A. D. Little Company is assisting the principal investigator in defining the experiment and developing the flight hardware.



MSFC Experiment No. 57

GRAVITY SIMULATION WORKBENCH

This experiment will explore engineering solutions to the problems arising from lack of gravity in the performance of maintenance and repair operations in space. Other than centrifugal force, which would often be inapplicable because of total system operational constraints, only two known sources of generation of force fields appear applicable. These are aerodynamic forces exerted by forced air flow through the work area and force induced by electrostatics.

The experimental apparatus consists of an enclosed volume fitted with ports through which the experimenter can insert his arms, a mesh work table and a fan system to force air "downward" through the work area. The experiment will consist of measuring the times required to disassemble and assemble selected typical small hardware items with and without airflow. The observed performance capability will be compared with that of the experimenter working with identical apparatus in a one-g environment.

MSFC Experiment No. 63&64

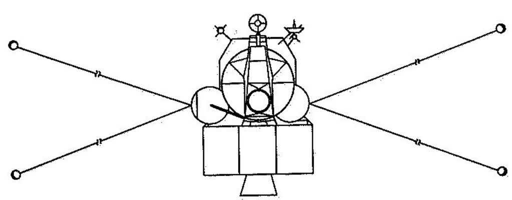
EXTENDIBLE ROD; GRAVITY GRADIENT STABILIZATION OF S-IVB

The objective of the experiment is to develop and demonstrate the necessary technology required for passive gravity gradient stabilization of large orbiting structures. Definition and design studies for experiment hardware requirements are being performed by the General Electric Company.

In applying passive gravity gradient stabilization techniques to spacecraft, the inherent moments of inertia of a body must be modified to achieve suitable system performance. The inertia modifications can be realized by extending masses on the tips of rods from the spacecraft. The use of extendible rods which are stored in a compact package and can be extended or retracted, on command, offers operational flexibility in producing changes in moments of inertia.

Passive gravity gradient stabilization of the S-IVB is achieved by using magnetically anchored, fluid dampers. The damper consists of two concentric spheres separated by a viscous fluid. The internal sphere contains a bar magnet field which locks the inner sphere to the earth's magnet field. The viscous fluid dissipates energy when relative motion takes place between the inner and outer spheres.

FOUR ROD CONFIGURATION FOR LOW ALTITUDE ORBIT



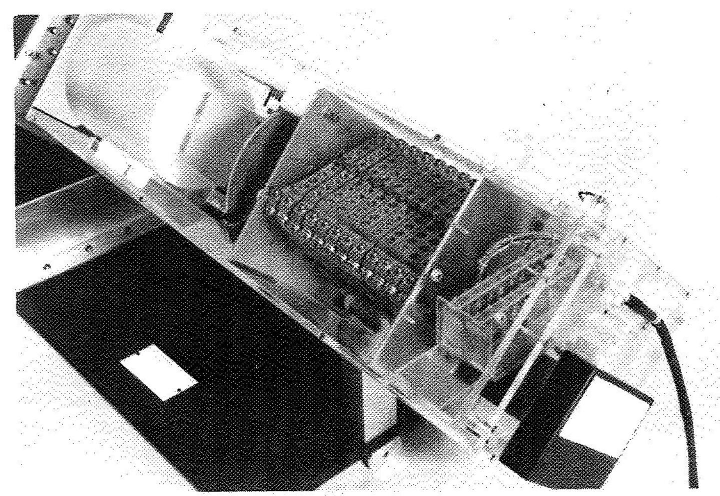
MSFC Experiment No. 65

FUSIBLE MATERIAL THERMAL RADIATOR

The objective of this experiment is to measure the effectiveness of a system utilizing a material specifically selected to undergo a phase change as the working material in a thermal radiator employed on an orbiting spacecraft. Comparison of performance of the system with that of more customary radiator configurations is planned.

Development of engineering models of the experimental hardware has been completed by the Northrop Corporation under contract to the Space Sciences Laboratory, MSFC.

ATM CONTAMINATION MONITOR

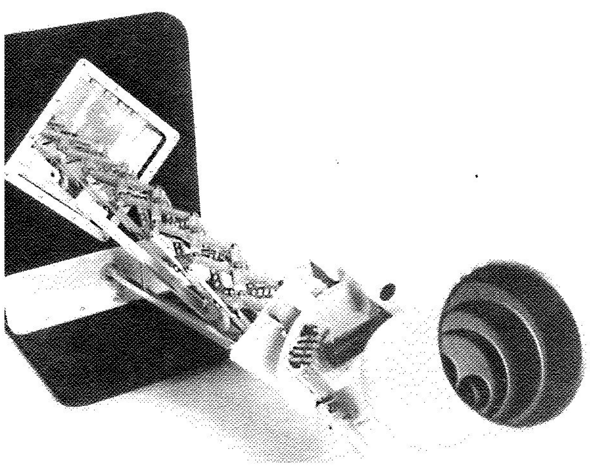


ANGLE VIEW MOCKUP EXTENSION MECHAN

MSFC Experiment No. 66

CONTAMINATION MEASUREMENT

Experiment design was accomplished by the Martin Company under the direction of Dr. Muscari. The contamination measurement experiment is intended to give preliminary information prior to the flight of the ATM about the effects of the local atmosphere created by a manned spacecraft on optical equipment and measurements. It will consist of two parts. The first is a surface degradation experiment in which samples of several different types of optical surfaces will be exposed to the environment, recovered, packaged, and returned to earth for study. Their optical properties will be compared with those of control samples and the extent of degradation will be determined. The second part of the experiment will determine the effect of this local atmosphere upon optical measurements. A photometer and a camera, sighted along the same axis, will determine the brightness of the light scattered from this local atmosphere as a function of angle away from the sun.



VIEW OF SUNSHIELD INTERIOR

MSFC Experiment No. 67

EARTH ALBEDO MEASUREMENT

This experiment will measure the albedo of selected areas of the earth. The measuring instrument will be hand-held and pointed at areas of interest. It will be capable of scanning the spectrum and obtaining intensity data in each of several bands. The data will be used both in basic geophysical studies and in refining thermal balance calculations for satellites. Directional information will be generated by the spacecraft motion.

MSFC Experiment No. 68

MEASUREMENT OF THE SOLAR CONSTANT

The experiment is designed to measure small variations of the solar constant predicted to be present but which are less than the observational error of ground based experiments. The data from this experiment will be used in refining thermal control calculations on future spacecraft as well as contributing to basic knowledge of the sun and the thermal balance of the earth. Since the variation of interest is extremely small, a high precision heliometer is required.

A laboratory model featuring fast-response and capable of approximately 0.01 percent precision is being developed by TRW, Incorporated.

MSFC Experiment No. 70

IONOSPHERE ELECTRON CONTENT

The ionosphere electron content experiment consists of a satellite which is designed to be placed in a geo-stationary orbit and to broadcast continuously on two frequencies. Observations of these radio transmissions with ground-based equipment will allow scientists to determine the electron content in a column of the atmosphere between the station and the satellite. The satellite will be built on an Early Bird body with the two transmitters being substituted for the Early Bird communications electronics. The required ground stations are now in existence and operating in support of other experiments. The satellite must be in a geo-stationary orbit in order that variations of the electron content with time in one section of the ionosphere can be observed. Current plans are for the satellite to be launched as a piggyback and then separated from the mother vehicle. If the launch is not into a zero degree inclination orbit, the Early Bird kick motors can be added to the package so that it will be capable of changing its inclination after separation from the mother spacecraft.

The ionosphere radio beacon satellite is being developed by the Hughes Aircraft Company.

MSFC Experiment No. 72

COSMIC RAY NEUTRON ALBEDO SPECTRUM

The cosmic ray neutron albedo experiment is planned to measure the flux and spectrum of neutrons emitted from the top of the earth's atmosphere as a result of cosmic ray interactions. These neutrons may be a major contributor to the neutron flux in the Van Allen belts. The neutron spectrometer is being developed at the Oak Ridge National Laboratories under the direction of Dr. F. C. Maienschein and will cover the range from 0.5 to 50 MeV. MSFC will assist by designing the instrument to meet specifications for survival and operation in space and by conducting tests to qualify.

MSFC Experiment No. 79

LUNAR ORBITING IR SPECTRORADIOMETER

An IR spectroradiometer mounted on a lunar orbiting vehicle can obtain infrared spectra of relatively small areas of the moon. By comparing these spectra with those generated in the laboratory, it will be possible to determine the rock and mineral types on the lunar surface and the size of the surface particles, as well as obtaining absolute temperature contours of the moon. Laboratory work is underway to obtain information on the infrared spectra of postulated lunar surface materials necessary for reduction of the data from this experiment.

MSFC Experiment No. 80

TWO PHASE FLOW HEAT TRANSFER

This experiment was originated and is being conducted by Dr. Harold Henry of the University of Alabama.

This experiment will determine the behavior of two phase vapor and/or gas liquid flow and heat transfer through porous beds, screens, and membranes in a low-g environment for possible applications to (a) water purification methods, (b) anti-vortexing and filtration devices in propellant tanks, and (c) separating liquid and vapor in low gravity environments by using capillary action. Measurements of liquid and gas flow rates, pressures, and temperatures within and across the porous beds, film record of bubble shapes and movements, velocities within pores, dissolved gas content and heating parameters, will be made.

MSFC Experiment No. 81

ENVIRONMENTAL COMPOSITION

This experiment was proposed and is being developed by the University of Michigan.

The Environmental Composition experiment is one of a possible series of experiments to define the constituents and density of the atmosphere created around a manned spacecraft by outgassing and rocket exhausts. It will consist of a mass spectrometer mounted on an extendible boom and three pressure gauges mounted around the spacecraft. The extendible boom will be used to place the spectrometer in several locations so that a map of the spacecraft atmosphere can be obtained.

MSFC Experiment No. 82

SPACE MANUFACTURING ALIGNMENT AID

This experiment will demonstrate the practicality and potential application of attitude change and control using a flywheel type momentum storage device for orientation and assembly of payloads in orbital flight. The application can range from astronaut orientation to the orientation of structural elements.

From the principle of conservation-of-momentum, it is known that the total momentum of a dynamic system remains constant unless the system is acted on by external forces. Consequently, if part of a spacecraft (or other object in space) is rotated about an axis, then the remaining part of the object will rotate in the opposite direction in order to conserve the system's angular momentum. Hardware will be designed and built to accommodate restrictions imposed by hard vacuum, zero-g, and safety requirements. Hardware will be of optimum utility and simplicity consistent with design constraints.

MSFC Experiment No. 84

SPACECRAFT SURFACES

The degradation of thermal control coatings as a function of wavelength has never been measured in the space environment and cannot be measured after a normal vehicle recovery since the values change on re-exposure to even a slight atmosphere. A hand-held spectroreflectometer is being developed so that measurements can be taken in-situ. The coating samples will then be placed in a container

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which will be pressurized with an inert gas for return to the laboratory. The samples will be closely examined in the lab and their reflectance properties remeasured so that comparison data will be available. Knowledge of the in-situ characteristics of the coatings and the relationship to laboratory data should lead to better thermal control calculations on future satellites.

MSFC Experiment No. 86

GRAVITY GRADIOMETER

This experiment is intended to demonstrate, in earth orbit, the operation of a gravity gradiometer which can be used to survey the gravitational field and locate anomalies in that field. An initial flight in the relatively well-known earth field will demonstrate the abilities of the instrument and provide confidence when it is used to map unknown fields, such as those of the moon and other planets. This sort of gravitational field survey can be used to locate areas of the planet's surface which might be of interest for further geophysical exploration. Since the gravity gradient is very small at orbital altitudes, an extremely sensitive gradiometer must be developed. Feasibility studies are in progress to determine if an instrument of this sensitivity can be integrated into a satellite system in such a manner that external influences will not mask the small gravitational gradient which is being measured. If the current feasibility studies indicate that a complete satellite system is possible, further development of the gradiometers will be pursued.

MSFC Experiment No. 87

LUNAR SURFACE IR SPECTRORADIOMETER

The IR spectroradiometer will provide ground-truth data for measurements of the infrared spectrum of the moon made from earth-based or orbiting instruments. It has been designed to be emplaced on the lunar surface by an astronaut who will initiate the data taking sequence and retrieve the data tape. The instrument is capable of scanning with the detector to obtain bi-directional measurement of the IR radiation and of simulating a lunar day with a built-in lamp although the sun will be the normal source of radiation. The laboratory model is being built by the Convair Division of General Dynamics Corporation.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GEORGE C. MARSHALL SPACE FLIGHT CENTER

MARSHALL SPACE FLIGHT CENTER, ALABAMA 35808

NASA